Beneficial Reuse of Waste Foundry Sand in Concrete

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I. INTRODUCTION

1.1-SYNOPSIS

Metal foundries use large amounts of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry and the remaining sand that is termed as foundry sand is removed from foundry. This study presents the information about the civil engineering applications of foundry sand, which is technically sound and is environmentally safe. Use of foundry sand in various engg. applications can solve the problem of disposal of foundry sand and other purposes.

Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, sea coal, resins) and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry Sand can be used as a partial replacement of cement or as a partial replacement of fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete. In the present study, effect of foundry sand as fine aggregate replacement on the compressive strength, split tensile strength and modulus of elasticity of concrete having mix proportions of M 25 grade was investigated.

Fine aggregates were replaced with three percentages of foundry sand. The percentages of replacements were 0,5,10,15,20,25,30,35,40,45 and 50% by weight of fine aggregate. Tests were performed for compressive strength, for all replacement levels of foundry sand at different curing periods (7&28-days).

Test results showed that there is some increase in compressive strength, after replacing the fine aggregates with certain percentage of foundry sand so foundry sand can be safely used in concrete for durability and strength purposes.

1.2-INTRODUCTION OF FOUNDRY SAND:

The industrial byproducts which have been disposed earlier are now being considered for beneficial use. Beneficial use can reduce our nation's carbon production and consumption of virgin material and result in economic gains. It is important component of nation's solid waste management hierarchy that first promotes source reduction and waste prevention followed by reuse, recycling, energy recovery and disposal. Researches all over the world today are focusing on ways of utilizing either industrial or agricultural wastes as a source of raw materials for the industry. These wastes utilization would not only be economical, but may also result to foreign exchange earnings and environmental pollution control.

The utilization of industrial and agricultural waste produced by industrial process has been the focus of waste reduction research for economical, environmental and technical reasons. This is because over 300 million tons of industrial wastes are being produced per annual by agricultural and industrial process in India. The problem arising from continuous technological and industrial development is the disposal of waste material. If some of the waste materials are found suitable in concrete making not only cost of construction can be cut down, but also safe disposal of waste material can be achieved.

The cement of high strength concrete is generally high which often leads to higher shrinkage and greater evaluation of neat of hydration besides increase in cost. A partial substitution of cement by an industrial waste is not only economical but also improves the properties of fresh and hardened concrete and enhance the durability characteristics besides the safe disposal of waste material thereby protecting the environment form pollution This paper deals with partial replacement of fine aggregate with the industrial waste from China Clay industries. The compressive strength, split tensile strength and flexural strength of conventional concrete and fine aggregate replaced concrete are compared and the results are tabulated.

The most critical problem we are facing now a day is the deficiency of artificial resources for the construction purpose. The reason behind this is the ban of on extraction of sand ordered by government. To solve this problem, we are using solid waste from industries as a replacement material for fine aggregate i.e. used foundry sand.

The foundry industry is diverse and complex. Although there are differences in some specific operations, the basic foundry processes vary only slightly from one foundry to another. The main foundry process produces metal or alloy castings by pouring molten metal into molds. The molds may be made of molding sand and core sand or may be of a permanent type made of metal and a refractory lining. After hardening, the castings are removed from the molds, processed and finished. The raw materials (sands) used for making foundry molds are usually recycled. However, after multiple uses, they lose their characteristics, thereby becoming unsuitable for further use in manufacturing processes, and all the raw materials are then discarded as waste.

Used Foundry sand (UFS) is a discarded material coming from ferrous and nonferrous metal-casting industry. It's a mixture of high quality size-specific silica sand, few amount of impurity of ferrous and nonferrous by-products from the metal casting process itself and a variety of binders. It can be reused several times in foundries but, after a certain period, cannot be used further and becomes waste material, referred to as used or spent foundry sand (UFS or SFS).

Many foundries have invested in sand reclamation systems that can recover up to 95 percent of sand used in the casting process. These systems represent an important environmental and

economic opportunity for foundries, helping to control production costs and to reduce the amount of waste for disposal. Even with this increase in sand reclamation, there is a limit to the number of times sand can be effectively reused in the casting process, eventually resulting in a large amount of used sand that could be beneficially reused elsewhere.

The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates. In modem foundry practice, sand is typically recycled and reused through many production cycles. The foundry Industry estimates that approximately 100 million tons of sand is used in production annually, of that 6-10 million tons are discarded annually and are available to be recycled into other products and are used in other industries. The automotive industries and its parts are the major generators of foundry sand. (About 95% of estimated used foundry sand).

SCOPE

The present work concerns the investigation of UFS utilization effect on both mortars and concretes. In particular, the performances of conglomerates (mortars and concretes), at different water/cement (w/c) ratios, are investigated. The aims is to establish the amount of used foundry sand that can be added in mixture without too heavy penalizations, principally in terms of workability, mechanical performances (i.e. compressive strength and dynamic elastic modulus) and drying shrinkage.

This research was conducted to investigate the performance of fresh and hardened concrete containing discarded foundry sands as a replacement of fine aggregate. A control concrete mix was proportioned to achieve a 28-day compressive strength of 25 MPa. Other concrete mixes were proportioned to replace 25% and 35% of regular concrete sand with clean/new foundry sand and used foundry sand by weight. Concrete performance was evaluated with respect to compressive strength.

Objective:

1. To economize the cost of construction without compromising with quality
2. To investigate the utilization of Used Foundry Sand as Fine aggregate and influence of UFS on the Strength on concrete made with different replacement levels
3. To check the effect of Used Foundry Sand in concrete on properties of fresh concrete & compressive strength
4. To check the suitability of Used Foundry Sand as an alternative construction material
5. To effectively utilize the waste material from the Foundries.
6. To reduce the problem of disposal of Foundry Waste.
7. To prove that the Foundry waste from Foundries can be a replacement for fine aggregate.
8. To study the physical properties of Foundries waste and are the ingredients in concrete.
9. To replace the fine aggregate by Foundry waste in different ratio such as 10,30,50,& 100 % in M20 mix concrete
10. To determine the compressive strength and compare it with the conventional concrete.

Proposed Work:

An extensive literature research was done and tests were conducted on byproduct samples to determine their physical properties to evaluate the possible uses. Total five mixes containing 0%,5%, 10%,15%,20%,25%, 30%,35%,40%,45%, 50%, 100% partial replacement of Artificial sand with used foundry sand for testing. Following test is carried out-

Axial Compressive Strength Test- Axial compression test is the most common test conducted on hardened concrete. The compression test is carried out on specimens' cubical shape. The cube specimen is of the size 150 X 150 X 150 mm. Hence in order to compare the compressive strength of sample block with that of standard concrete block of 100% artificial resources.

Research Significance:

This investigation was directed toward obtaining strength and durability data on concrete incorporating used foundry sands. The results of this investigation were used to establish material specifications for concrete containing used foundry sand for architectural precast concrete panels and other similar applications. This should lead to increased utilization of used foundry sand in the manufacture of concrete for varied applications.

II. LITERATURE REVIEW

2.1Naik et al. (1987)

He carried out a research on Utilization of Used Foundry Sand in Concrete. This research was conducted to investigate the performance of fresh and hardened concrete containing discarded foundry sands in place of fine aggregate. A control concrete mix was proportioned to achieve a 28-day compressive strength of 38 MPa. Other concrete mixes were proportioned to replace 25% and 35% by weight of regular concrete sand with clean/new foundry sand and used foundry sand. Concrete performance was evaluated with respect to compressive strength, tensile strength, and modulus of elasticity. At 28-day age, concrete containing used foundry sand showed about 20-30% lower values than concrete without used foundry sand. But concrete containing25% and 35% clean/new foundry sand gave almost the same compressive strength as that of the control mix.

2.2 Reddi et al. (1995):

He reported that compressive strength of stabilized foundry sands decreases as the replacement proportion of foundry sand increases in the mixes and the strength is achieved relatively faster with fly ash than with cement. Cement and fly ash mixtures were prepared using 0%, 25%, 50%, 75%, & 100% levels of replacement of silica sand by foundry sand.

Initial experiments with class F fly ash were unsuccessful because it lacked cementitious properties to form a stable mix therefore subsequent experiments were restricted to class C fly ash only. The ratio of water to the cementitious binder was chosen to be 1.0 in the case of Portland cement and 0.35 in the case of fly ash. The samples were founded in PVC pipes, 2.85 cm in dia. and 5.72 cm long. The mixtures of sands and the binders were poured into these pipes and then vibrated on a vibrating table to minimize air pockets. For each of the

replacement levels, compressive strengths were obtained after 3, 7, 14, 28, & 56 days in order to evaluate the difference due to curing time. The clay bonded foundry sand reduced the strength of the stabilized mixes more than the resin- bonded foundry sands. A similar observation is made in context of fly ash stabilization. The drastic reduction in strength with an increase in clay bonded foundry sand replacement is apparent in the cases of both fly ash & cement.

Cement – stabilized mixes acquired their strength considerably slower than fly ash stabilized mixes. After 7 days of curing the cement-stabilized RBS reached only 30% of peak strength whereas its fly ash counterpart achieved 80% of its peak strength.

2.3Naik et al. (1997):

He carried out the research on the effect of the clean as well as used foundry sand on the compressive strength of the concrete by using cube as well as cylinder block. He reported that compressive strength increased with age. To determine the compressive strength, 150mm × 300mm diameter cylinders were made for each flow able slurry mixtures. The compressive strength for all slurry mixtures with and without foundry sand varied from 0.17 to 0.4 Mpa at the age of 7 days. The compressive strength values ranged from 0.27 to 0.55MPa for the fly ash F1 mixtures and 0.3 to 0.6Mpa for the fly ash F2 mixtures at 28 days.

Compressive strength increased with an increasing amount of foundry sand up to certain limit, and then decreased. The strength data revealed that excavatable flow able slurry with up to 85% fly ash replacement with clear and used foundry sand can be manufactured without significantly affecting the strength of the reference mixtures. To obtain a relatively high strength at the age of 28 days and beyond for mixtures tested, fly ash replacement with foundry sand should be maintained between 30 & 50%. The amounts of foundry sand corresponding to the maximum compressive strength values were 50% for clean and clear sand for fly ash F1 mixture,30% for used sand for fly ash F1 mixture, 70% for clean sand for fly ash F2 mixture and30% for used sand for fly ash F2 mixture at the age of 91 days. The maximum Compressive strength for both fly ash mixtures were obtained at 30% fly ash replacement with the used foundry in spite of variation in the mixture design and source of fly ash.

2.4 Naik et al. (2001):

He reported that the min. permeability was observed at 30% fly ash replacement with foundry sand. All specimen preparations were done in accordance with ASTM C192. The permeability of mixtures was evaluated in accordance with ASTM D5084. The permeability of fly ash F1 slurry mixtures varied from 4×10-6cm/s to 72 ×10-6cm/s and for fly ash F2 the slurry mixture varied from 5×10-6cm/s to 69×10-6cm/s. The permeability for both the fly ash mixtures were only slightly affected by the increasing foundry sand content for up to 70% fly ash replacement at the age of 30 days.

The min permeability value was observed at 30% fly ash replacement level with foundry sand. However it increased abruptly when the replacement levels for the fly ashes with foundry sand were increased to 85% from 70%. The increase may be attributed to the increase in voids produced by the increase in the amount of foundry sand and to the decrease in theamount of finer particles of fly ash in the mixture. There was no significant effect offoundry sands (clean or used) on the permeability values of mixtures tested. So the permeability of test mixtures were not significantly influenced by inclusion of foundry sand up to 70% fly ash replacement and at 85% replacement of foundry sand a sharp increase in permeability was observed.

2.5RafatSiddique, Geert de Schutter, Albert Noumowe et al. (2007)

He carried out a research on the effect of used-foundry sand on the mechanical properties of concrete. He invested that used-foundry sand is a by-product of ferrous and nonferrous metal casting industries. Foundries successfully recycle and reuse the sand many times in a foundry. After so many usages it will be an industrial waste and a research is being carried out for its possible large-scale utilization in making concrete as partial replacement of fine aggregate in a concrete.

It includes the results of an experimental investigation carried out to evaluate the mechanical properties of concrete mixtures in which fine aggregate (regular sand) was partially replaced with used-foundry sand (UFS). Fine aggregate was replaced with three percentages (10%, 20%. and 30%) of UFS by weight. Tests were performed for the properties of fresh concrete. Compressive strength, splitting- tensile strength, flexural strength, and modulus of elasticity were determined at 28, 56, 91, and 365 days. Test results indicates a marginal increase in the strength properties of plain concrete by the inclusion of UFS as partial replacement of fine aggregate (sand) and that can be effectively used in making good quality concrete and construction materials.

Following conclusions can be drawn from the present investigation:

1. Compressive strength, splitting-tensile strength, flexural strength, and modulus of elasticity of concrete mixtures increased with the increase in foundry sand contents.
2. Compressive strength, splitting-tensile strength, flexural strength, and modulus of elasticity of concrete mixtures increased with age for all the foundry sand contents.
3. Increase in compressive strength varied between 8% and 19% depending upon UFS percentage and testing age, whereas it was between 6.5% and 14.5% for splitting-tensile strength, 7% and 12% for flexural strength, and 5% and 12% for modulus of elasticity.
4. Results of this investigation suggest that used-foundry sand could be very conveniently used in making good quality concrete and construction materials.

2.6YucelGuney et al. (2009)

He carried out a research on the Re-Usage of Waste Foundry Sand In High-Strength Concrete. In this study, the partial re-use of waste foundry sand in high-strength concrete production was investigated. The artificial fine sand is replaced with waste foundry sand (0%, 5%,10 **%**and 15%). The findings from a series of test program has shown reduction in compressive and tensile strengths, and the elasticity modulus which is directly related to waste foundry inclusion in concrete. The concrete with

10% waste foundry sand exhibits almost similar results to that of the control one. The slump and the workability of the fresh concrete decreases with the increase of the foundry sand ratio.

III. BACKGROUND INFORMATION

3.1 Foundry Sand:

Foundry sand is high quality silica sand that is by product from the production of both ferrous and non-ferrous metal castings. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates.

3.1.1 Origin:

Foundries purchase high quality size-specific silica sands for use in their molding and casting operations. The raw sand is normally of a higher quality than the typical bank run or artificial sands used in fill construction sites.

The sands form the outer shape of the mold cavity. These sands normally rely upon a small amount of bentonite clay to act as the binder material. Chemical binders are also used to create sand “cores”. Depending upon the geometry of the casting, sands cores are inserted into the mold cavity to form internal passages for the molten metal. Once the metal has solidified, the casting is separated from the molding and core sands in the shakeout process.

In the casting process, molding sands are recycled and reused multiple times. Eventually, however, the recycled sand degrades to the point that it can no longer be reused in the casting process. At that point, the old sand is displaced from the cycle as byproduct, new sand is introduced, and the cycle begins again.

3.1.2 Production:

Foundry sand is a produced by five different foundry classes. The ferrous foundry gray iron, ductile iron and steel produce the most sand. Aluminium, copper, brass and bronze produce the rest. The sand is typically used the multiple times within the foundry before it becomes a byproduct; only 10% of the foundry sand was reused. The sand from the brass, bronze and copper foundry are generally not reused. While exact numbers are not available, the best estimate is that approximately 10 million tons of foundry sand can beneficially be used annually.

3.1.3 Uses:

Foundry sand is basically fine aggregate. It can be used in many of the same ways as artificial or manufactured sands. This includes many civil engineering applications such as embankments, flow able fill, hot mix asphalt (HMA) and Portland cement concrete (PCC). Foundry sands have also been used extensively agriculturally as topsoil. Currently, approximately 500,000 to 700,000 tons of foundry sand are used annually in engineering applications. The largest volume of foundry sand is used in geotechnical applications, such as embankments, site development fills and road bases.

3.1.4 Types of Foundry Sand

There are two basic types of foundry sand available:

a) Green Sand

b) Chemically Bonded Sand

a) Green Sand:

Green sand consists of 85-95% silica, 0-12% clay, 2-10% carbonaceous additives, such as seacoal, and 2-5% water. Green sand is the most commonly used molding media by foundries. The silica sand is the bulk medium that resists high temperatures while the coating of clay binds the sand together. The water adds plasticity. The carbonaceous additives prevent the "burn-on" or fusing of sand onto the casting surface. Green sands also contain trace chemicals such as MgO, K2O, and TiO2.

b) Chemically Bonded Sand

Chemically bonded sand consists of 93-99% silica and 1-3% chemical binder. Silica sand is thoroughly mixed with the chemicals; a catalyst initiates the reaction that cures and hardens the mass. There are various chemical binder systems used in the foundry industry. The most common chemical binder systems used are phenolic-urethanes, epoxy-resins, furfyl alcohol, and sodium silicates.

3.1.5 FOUNDRY SAND OPERTAION

Historically, individual foundries have typically developed their own customer base. But over time, foundries have joined together to create regional foundry consortia to pool resources and to develop the recycled foundry sand industry. FIRST (Foundry Industry Recycling Starts Today) is a national coalition of member foundries. FIRST focuses on market development of sustainable options for beneficial reuse of foundry industry byproducts.

3.1.6 Foundry Sand Physical Characteristics:-

3.1.6.1 Particle Size and Shape

Foundry sand is typically sub angular to round in shape. After being used in the foundry process, a significant number of sand agglomerations form (Figure 3.1). When these are broken down, the shape of the individual sand grains is apparent.

Figure 4. Unprocessed foundry sand

3.1.6.2 COLOUR

Green sands are typically black, or gray, not green! (Figure 6). Chemically bonded sand is typically a medium tan or off-white color.

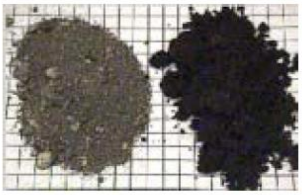


Figure 6. Green sands from a gray iron foundry (after processing and screening)

3.1.6.3 Durability/Soundness

Durability/Soundness of foundry sand is important to ensure the long-term performance of civil engineering applications. Durability of the foundry sand depends on how the sand was used at the foundry. Successive molding can cause the foundry sand to weaken due to temperature shock. At later stages of mold use, this can lead to the accelerated deterioration of the original sand particles. However, in civil engineering uses, the foundry sand will not normally be subjected to such severe conditions. In geotechnical applications, foundry sand often demonstrates high durability.

3.1.6.4 Chemical Composition

Chemical Composition of the foundry sand relates directly to the metal molded at the foundry. This determines the binder that was used, as well as the combustible additives. Typically, there is some variation in the foundry sand chemical composition from foundry to foundry. Sands produced by a single foundry, however, will not likely show significant variation over time. Moreover, blended sands produced by consortia of foundries often produce consistent sands. The chemical composition of the foundry sand can impact its performance.

3.2 BENEFICIAL REUSES OF FOUNDRY SAND

Foundry sand can be suitable for a variety of beneficial reuses. Terminology for defining uses varies across states. For the purposes of this report, EPA has developed definitions for common uses of sand in consultation with industry experts. The following are uses of foundry sand approved in one or more states:

3.2.1 Structural Fill

Foundry sand can be used as support for structures such as roadways, parking lots, buildings, and pieces of equipment. "Encapsulated" structural fill may involve the use of a liner, cap, or cover, generally made of a clay material, which prevents water from percolating through the foundry sand and minimizes the potential for leaching.

3.2.1 Manufacturing another Product

Foundry sand is useful as a raw material in manufacturing other products, such as controlled, low-strength material (CLSM or flowable fill), asphalt, cement, concrete, grout, lightweight aggregate, concrete block, bricks, roofing materials, plastics, paint, glass, ceramics, and rockwool. Specific examples of these uses include:

• *Flowable fill*:

Flowable fill is a liquid-like material that self-compacts and is used as a substitute for conventional soil backfill. The product is easily transported and can be readily re-excavated. The typical mixture contains sand, fly ash, Portland cement, and water. Foundry sand can readily be substituted for virgin sand in flowable fill mixtures.

• *Cement and Concrete*:

Sand is a component of Portland cement and concrete. Portland cement requires sand with a silica content of at least 80 percent, which most foundry sands meet. It also requires certain minerals such as iron and aluminum oxides, which are found in many foundry sands. Cement and additional sand or gravel are components of concrete, allowing further reuse of foundry sand.

3.2.2 Soil Manufacturing and Amendment

Commercial soil blending operations can use foundry sand to produce horticultural soils, topsoil, potting soil, and turf mixes. These soil products are typically mixtures of sand or gravel with peat, fertilizers, and/or top soil. Foundry sand can also improve the performance of agricultural soils, and can be used as a composting ingredient.

3.2.3 Landfill Uses

Foundry sand can be used as a cover for the working face of an active landfill, for road construction within the active cell, or as a substitute for virgin aggregate in the construction of drainage layers for landfill leachate collection systems.

3.2.3 Pipe Bedding and Backfill

Foundry sand can serve as backfill for trenches created by the installation of storm and sanitary sewer lines.

3.2.4 Asphalt:

This is an application where foundry sand has been used in asphaltic (bituminous) concrete consisting of a mixture of aggregates bound together by asphalt cement.

3.2.5 Portland Cement:

Portland cement application where foundry sand has been used in the production of Portland cement (concrete). Concrete consists of a mixture of 30% sand, 50% gravel, 15% cement and 55% water. Concrete can be cast-in-place or pre-cast into concrete products such as bricks, pipes and blocks.

3.2.6 Rock Wool:

Rock wool fibers are commonly used to reinforce other materials, such as building material insulation, and are similar to fiber glass. Rock wool is produced by combining blast furnace slag with silica or alumina in a cupola and then converting the molten material into fibers. Foundry sand has proved to be an effective source of silica in rock wool. In order for the foundry sand to be used, it must first be pretreated and formed into briquettes.

3.2.7 Fine Aggregate for Concrete Block

Foundry sand has been used as a source of fine aggregate in the production of concrete block. The ultimate use, shape, and size of the product governs the type and gradation of the aggregate required in the concrete mixture.

Alternative Daily Cover

Foundry sand has been used quite successfully as an alternative cover material to the traditional 6 inches of daily soil cover required by states for active faces of a landfill. This is especially useful when a landfill operation does not have an abundant supply of on-site cover soil.

3.2.8 Hydraulic Barrier In Landfill Final Cover

Foundry sand (green sand) with clay content in excess of 6 percent, a liquid limit of greater than 20, and a plasticity index of greater than 3 has been shown to exhibit a low permeability. Studies have shown that foundry sand possessing these characteristics can be used for final cover at landfills.

Concrete is a mixture comprised of cement (10-15 percent), coarse and fine aggregates (60-75 percent) and water (15-20 percent) by volume. Foundry sand can be used as a fine aggregate substitute in PCC concrete. Fine aggregates are generally 3/8 inch or smaller, while coarse aggregates are 3/8 to 2 inches in diameter. Foundry sand meets two of the critical requirements for concrete aggregates: it is uniformly graded, and is strong, hard, and durable.

Concrete mix designs require a range of aggregate sizes, with fine aggregate making up between 20 and 35 percent of the total volume of the mix. Particle size distribution or gradation is critical to the performance of the resulting concrete. In most instances, foundry sands are too fine to allow for total substitution for the fine aggregate in a concrete mix. Foundry resin sands, lacking the finer clay particles, are often a better substitution for virgin concrete sands than are green sands.

Concrete mixes have been successfully proportioned with fine aggregate replacement ranges from 25 to 45 percent foundry sand. Some concrete mixes exhibit lower initial compressive strengths when manufactured with foundry sand, so it is important to batch test sands from individual foundry sources before scaling up to full project use. Foundry sand mixes may also require higher water ratios, due to the presence of clay and other binder materials. In general, resin sands have fewer performance limitations than foundry green sands and should demonstrate compressive strengths, tensile strengths and modulus of elasticity values similar to those of concrete produced with virgin sands.

Utilization of used foundry sand in concrete can consume a large volume of used foundry sand generated in the United States. However, before wide-spread commercial use of concrete containing used foundry sand, long-term strength and durability data are needed for developing material specifications for potential users. There are a lack of data on long-term strength and durability of such concrete systems. Therefore, this research was based on fieldwork; it was primarily focused toward determining strength and durability of concrete made with used foundry sand.

IV. METHODOLOGY

4.1 Experimental Methodology

According to the objective of the project the minimum requirement of the strength of the structure is decided i.e. M25and from that mix design for M25 concrete is carried out and sampling has been decided and from that the overall quantity of the material has been calculated and material is purchased.

Before casting to find out the property of materials different tests on cement has been done such as normal consistency, initial & final setting time, soundness & fineness tests, etc. The sieving of CA through 20 mm sieve and the fine aggregate through 4.75 mm sieve is done and the sieving of Used Foundry Sand before grinding & after grinding is done for getting appropriate results. The trial mix is done with water cement ratio 0.43. The concrete blocks are casted with UFS as a Fine Aggregate in Concrete. There are three blocks for each trial mix for 28 days testing. Then the mix for water cement ratio 0.43 is final according to compliance requirement is adopted. Then the final casting has been done as per the above mix design by using 0, 10%, 30%, 50%, 100% Foundry Sand for 28 days testing and for each % there are five samples for each testing day and each sample there are three blocks.

4.2 MATERIAL PROPERTIES

4.2.1 Cement

Cement is a binder, a substance that sets and hardens independently, and can bind other materials together. Cement used in construction is characterized as hydraulic or non-hydraulic. Hydraulic cements (e.g., Portland) harden because of hydration, chemical reactions that occur independently of the mixture's water content; they can harden even underwater or when constantly exposed to wet weather. The chemical reaction that results when the anhydrous cement powder is mixed with water produces hydrates that are not water-soluble. Cement is fine grey powder. It is mixed with water and material such as sand gravel, and crushed stone to make concrete. 53grade ordinary Portland cement (ACC cement) was used for all casting. Testing of cement is done as per the IS: 8112-1989.
The results are given below.

4.2.2 Fine Aggregate

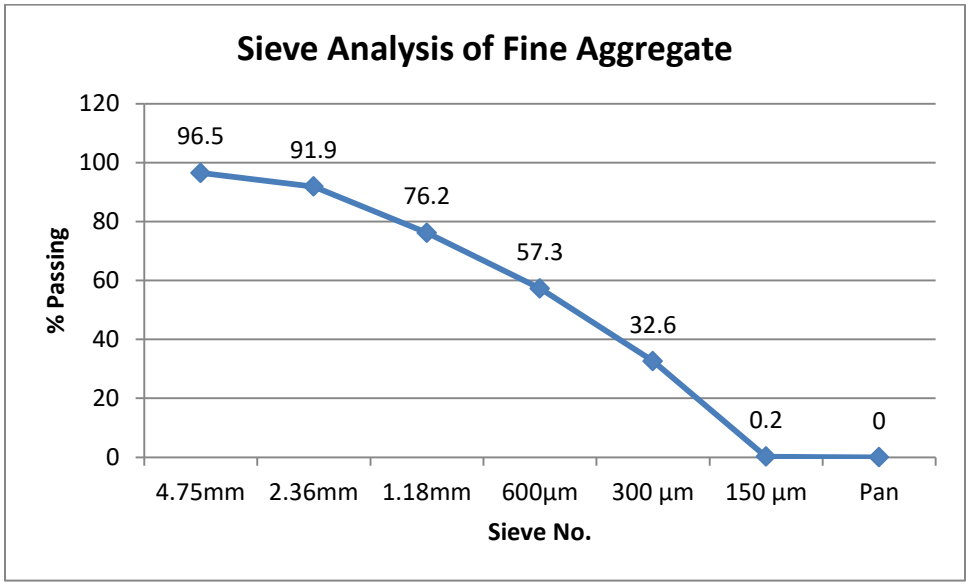
Fine aggregate isdefined as aggregate whose size is 4.75 mm and less. For increased workability and for economy as reflected byuse of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent. Artificial sand with 4.75mm maximum size is used as per IS: 383-1970. It satisfied all requirements. Results are given in table.

Sr. No.	Characteristics	Value
1.	Type	Natural
2.	Specific gravity	2.6
3.	Total water absorption	3.45%
4.	Fineness modulus	2.453
5.	Grading zone	III

Table No 3.2-Properties of Fine Aggregate

Sr. No.	Sieve No.	Weight Retained (gms)	Cumulative Weight Retained (gms)	% Retained	% Passing
1.	4.75mm	35	35	3.5	96.5
2.	2.36mm	235	270	27	73
3.	1.18mm	320	590	59	41
4.	600µm	189	779	77.9	22.1
5.	300 µm	135	914	91.4	8.6
6.	150 µm	56	970	97	3
7.	75µm	17	987	98.7	1.3
8.	Pan	13	1000	100.0	0.00

Table No 3.3- Sieve analysis of Fine Aggregate



4.2.3 Coarse Aggregate

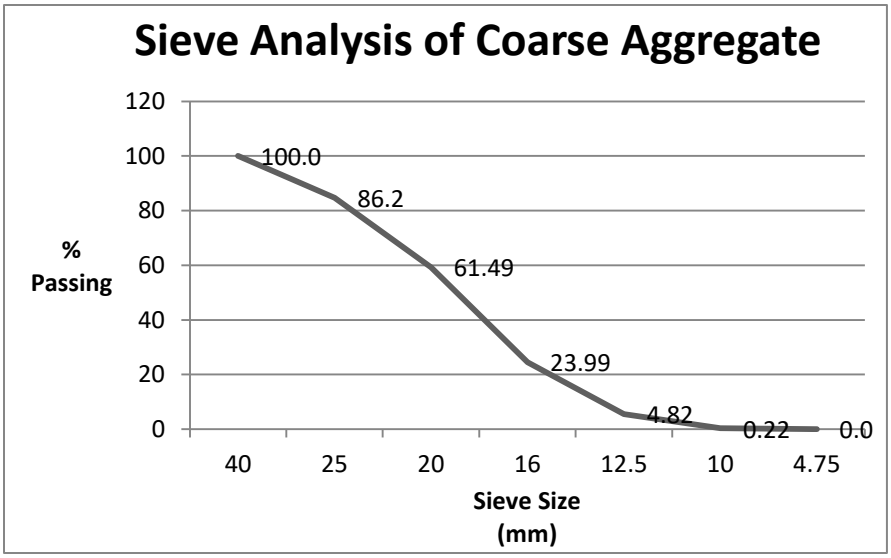
Coarse Aggregate is defined as whose size is bigger than 4.75 mm. It should be angular shaped for possessing well defined edges formed at the intersection of roughly planar faces. Locally available coarse aggregate having maximum size 20mm is used. It is tested as per IS: 383-1970. Results are given in table.

Sr. No.	Characteristics	Value
1.	Type	Crushed
2.	Maximum size	20mm
3.	Specific gravity	2.89
4.	Total water absorption	1.2%
5.	Fineness Modulus	8.02
6.	Shape	Angular

Table 3.4-Properties of Coarse Aggregate

Sr. No.	Sieve Size	Wt. Retained	Cumulative Retaining	% Retaining	% Passing
1	40	0	0	0.00	100.00
2	25	138	138	13.8	86.2
3	20	247.1	385.1	38.51	61.49
4	16	375	760.1	76.01	23.99
5	12.5	191.7	951.8	95.18	4.82
6	10	46	997.8	99.78	0.22
7	4.75	2.2	1000	100	0.00

Table 3.5- Sieve analysis of Coarse Aggregate



4.2.5 Used Foundry Sand

Used Foundry sand is obtained locally. It is used as a partial replacement (0%, 10%, 30%, 50%, & 100%) to the fine aggregate (Artificial Sand). The tests are conducted on UFS for its physical properties. Results are given in table

Sr. No.	Sieve No.	Weight Retained (gms)	Cumulative Weight Retained (gms)	% Retained	% Passing of Foundry Sand
1.	4.75mm	2.0	2.0	0.20	99.9
2.	2.36mm	9.2	11.2	1.12	98.95
3.	1.18mm	25.3	36.5	3.65	96.40
4.	600µm	30.0	66.5	6.65	92.80
5.	300 µm	432.3	498.8	49.88	50.3
6.	150 µm	456.2	955	95.5	4.5
7.	75 µm	45.0	1000	100.0	0.0
			Sum of Cumulative Weight Retained (gms)	257.0	

Table No 3.3- Sieve analysis of Used Foundry Sand

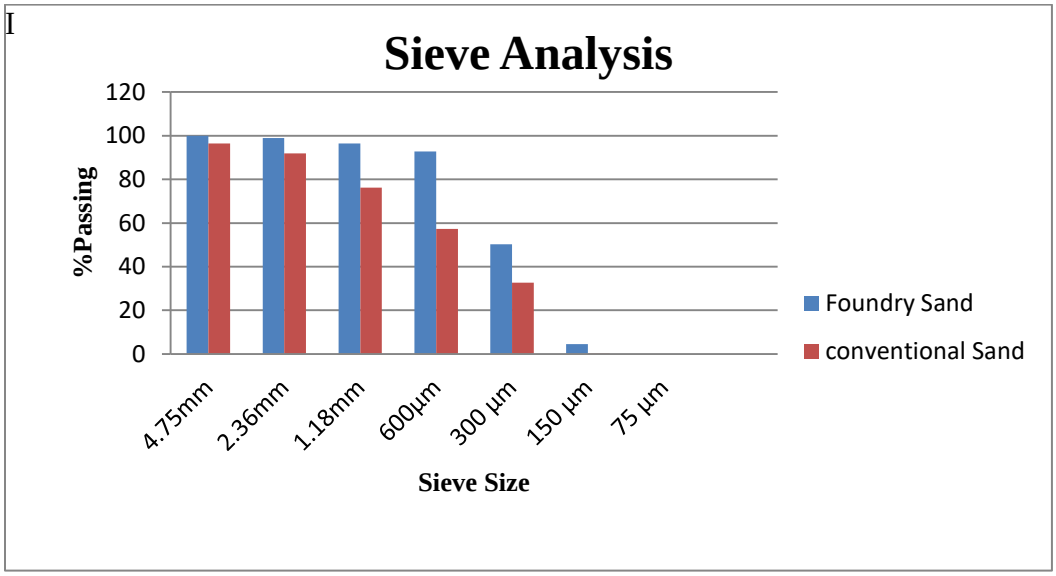
Fineness Modulus=$Sum\ of\ Cumulative\ Weight\ Reatined\ \frac{gms}{100}$

= 257.00/100

= 2.57

Zone of Foundry Sand:-**Zone IV**

I



4.2.4 Water

The water used for mixing and curing should be clean and free from injurious quantities of alkalis, acid, oils, salt, sugar, organic materials, vegetable growth and other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing. The pH value of water should be not less than 6. Generally, water that is suitable for drinking is satisfactory for use. Water from lakes and streams that contain marine life also usually is suitable. When water is obtained from sources mentioned above, no sampling is necessary. When it contains sewage, mine water, or wastes from industrial plants or canneries, it should not be used in the mix, unless tests indicate that it is satisfactory, Water from such sources should be avoided since the quality of the water could change due to low water or by intermittent discharge of harmful wastes into the stream. In the present experimental programme, potable tap water is used for casting.

4.3 MIX DESIGN

Concrete Mix Design of M 25 by I.S code Method (IS 10262-2009):

Mix design is the process of selecting suitable ingredients of concrete and determining their relative proportion with the object of producing concrete of certain minimum strength and durability as economical as possible.

a. The first object is to achieve the stipulated minimum strength and durability.
b. The second object is to make concrete in the most economical manner.

A) Design Stipulation:

1) Grade designation : M 25
2) Type of cement : OPC 53 grade conforming to IS 8112
3) Maximum nominal size of aggregate : 20 mm
4) Minimum cement content : 360 kg/m^3
5) Maximum water-cement ratio : 0.43
6) Workability : 50 mm (Slump)
7) Exposure condition : Extreme
8) Degree of supervision : Very Good.
9) Type of aggregate : Crushed angular aggregate.
10) Maximum cement content : 450 kg/m^3
11) Chemical admixture type : None

B) Test date for material:

1) Cement used : OPC 53 grade conforming to IS 8112.
2) Specific gravity of cement : 3.15
3) Chemical admixture : None
4) Specific gravity for:
   A. Coarse aggregate : 2.89
   B. Fine aggregate : 2.6
5) Sieve analysis:
   A. Fine aggregate : Zone III

C) Target mean strength:

Target mean strength for specified characteristic cube strength is

$$f'_{ck} = f_{ck} + 1.65\,\delta$$

Where

f'_{ck}= Target Average Compressive Strength at 28 days,
f_{ck}= Characteristic Compressive Strength at 28 days, and
δ= Standard Deviation.

From Table 1, Standard Deviation, δ= 4 N/mm^2

Therefore,

Target Mean Strength = 25 + 1.65 X 4.0 = 31.6 N/mm^2

D) Selection of water cement ratio:

From Table 5 of IS 456, maximum Water-Cement ratio = 0.55
Based on W/C graph, adopt Water-Cement ratio = 0.43
0.43<0.55,
Hence OK

E) Selection of Water Content:

From Table 2, maximum water content = 186 litre (for 25 to 50 mm slump range) for 20 mm aggregate
Estimated water content for 50 mm slump = No correction (if slump range in 25-50 mm)

F) Calculation of Cement Content:

Water-Cement ratio = 0.43
Cement Content = (186/0.43) = 432.55 kg/m^3
From Table 5 of IS 456, minimum cement
Content for 'Extreme' exposure condition = 360 kg/m^3
432.55 Kg/m^3> 360 Kg/m^3, hence O.K.

G) Calculation of Fine Aggregate and Coarse Aggregate Content:

For specified maximum size of the aggregate of 20mm, the amount of entrapped air in the wet concrete, is 2 percent.

$$V = \left[(\text{Required Water Content}) + \left[\frac{\text{Cement Content}}{\text{Sp. Gravity of Cement}} \right] + \frac{1}{3.15} \times \frac{\text{Fine Agg. Content}}{\text{Sp.Gravity of Fine Agg.}} \right] \times \frac{1}{1000}$$

$$0.98 = \left[186 + \frac{432.55}{3.15} + \frac{1}{3.15} \times \frac{F_a}{2.6} \right] \times \frac{1}{1000}$$

$$F_a = 537.82_{\text{Kg/m}^3}$$

$$C_a = \frac{1-0.315}{0.315} \times F_a \times \frac{2.6}{2.6}$$

$$C_a = \frac{1-0.315}{0.315} \times 537.82 \times \frac{2.6}{2.6}$$

$$C_a = 1169.55_{\text{Kg/m}^3}$$

According to Actual condition:

Water	Cement	Fine Aggregate	Coarse Aggregate
186Kg/m^3	**432.55 Kg/m^3**	**537.82 Kg/m^3**	**1169.55 Kg/m^3**
0.43	**1.00**	**1.24**	**2.70**

4.4 Mixing process adopted:

The concrete shall be mixed by hand or preferably, in a laboratory batch mixer, in such a manner as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens.

4.5 Testing of Concrete

The main objective of testing was to know the behavior of concrete with replacement of Used Foundry Sand to some percentage to Fine Aggregate at room temperature.

The main parameters studied were compressive strength and workability test. The materials used for casting concrete samples along with tested results are described and in this project we are going to compare the strength of concrete block by using zero percentage Used Foundry Sand with the concrete block using some percentage of Used Foundry Sand by following test. At the same time we were studied the effect of Used Foundry Sand on the workability, segregation and bleeding of concrete at the time of casting.

4.5.1 Compressive Strength Test

Compression test is the most common test conducted on harden concrete, partly because it is an easy test to perform and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The standard compressive strength of concrete is determined through compression tests performed on concrete cube of size 15 × 15 ×15 cm. Freshly mixed concrete is filled in metal moulds. The specimens are taken out of the moulds after 24 hours and moist-cured for 28 days. After completion of above days the cubes are tested by loading them till failure using a compression machine. The recorded load value P at failure is used to determine the compressive strength.

a) Aim

To determine the compressive strength of concrete specimens prepared and to verify the strength requirements as desired in the mix design and stipulated in the IS code 516.

b) Apparatus

Compression Testing Machine

c) Specimen

15 cubes of 15 cm size of mix M25.

d) Mixing

Through mixing of the concrete by machine mixing (Drum type concrete mixer).

e) Hand Mixing

i. Mix the cement and fine Aggregate on a water tight non-absorbent platform until the mixture is thoroughly blended and is of uniform colour.
ii. Add the coarse aggregate and mix with the cement and fine aggregate until the coarse aggregate is uniformly distributed throughout batch.
iii. Add water and mix until the concrete appears to be homogenous and of the desired consistency.

f) Method of Compaction

i. Clean the mould and apply oil.
ii. Keep the mould on vibrating table.
iii. Fill the concrete in the moulds in layers approximately 5 cm thick.
iv. Vibration is given for 2 minutes.
v. Compact each layer with not less then 35 strokes per layer using a tamping rod
(Steel bar 16mm diameter and 60cm long, bullet pointed at lower end).
vi. Level the top surface and smoothen it with a trowel. Vibration is given for 2 minutes.

g) Curing

The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the moulds and kept submerged in clear fresh water until taken out prior to test.

h) Procedure

i. Remove the specimen from water after specified curing time and wipe out excess water from the surface.
ii. Take the dimensions of the specimen.
iii. Clean the bearing surface of the testing machine.
iv. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
v. Align the specimen centrally on the base plate of the machine.
vi. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
vii. Apply the load gradually without shock and continuously at the rate of 6 KN/sec till the specimen fails.
viii. Record the maximum load at failure.

V. RESULTS AND DISCUSSIONS

5.1 Compressive strength

Compression test is the most common test conducted on harden concrete, partly because it is an easy test to perform and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

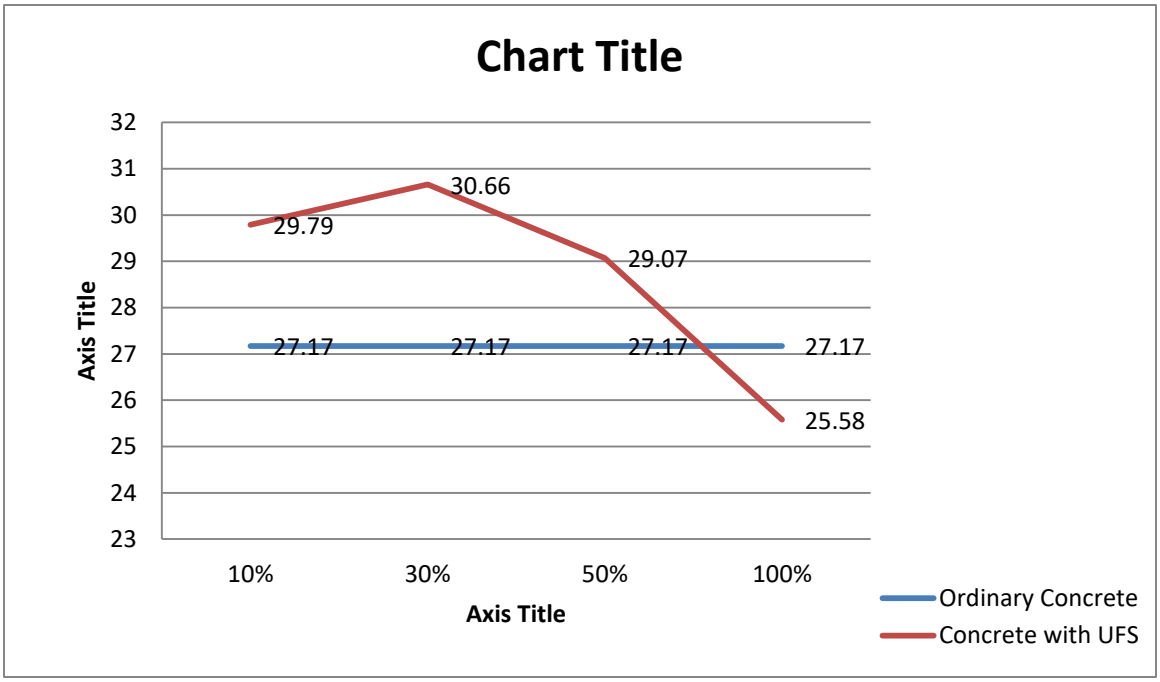
In this test, the values of compressive strength for different replacement levels of bagasse ash contents (0%,10%,30%,50%,&100%)at the end of different curing periods (28 days) are given in table. These values are plotted in figure and which show the variation of compressive strength cement replacement at different curing ages respectively.

Foundry Sand Replacement %	**compressive strength of concrete blocks(N/mm^2)**	**% difference in Compressive Strength of concrete blocks with 0% of Used Foundry Sand**
	28 days	28 days
0%	27.17	0
10%	29.79	9.64%
30%	30.66	12.84%
50%	29.07	6.99%
100%	25.58	-5.85%

Table No.5.1-Result Compressive Strength Comparison with 0% Replacement.

Sample No.	**0%**	**10%**	**30%**	**50%**	**100%**
1	28.34	29.64	30.52	27.90	26.16
2	26.16	30.52	30.08	26.18	30.52
3	27.03	29.21	31.39	33.13	20.05
Average	**27.17**	**29.79**	**30.66**	**29.07**	**25.58**

Table No 5.2 -Result of 28 days compressive strength



Graph No 5.1 - 28 days compressive strength Comparison

Comment:

From the graph of 28 days Compressive Strength Comparison, it can be seen that compressive strength of concrete with partial replacement of Used Foundry Sand (0% to 30%)has increased upto 30% replacement and after that goes on decreasing as compared to concrete mix withnatural sand.

The Compressive Strength of Concrete mix with 10%, 30%, 50% Foundry Sand has increased as compared to Concrete Mix with artificial Sand. The % increase is in the range of 6% to 13% as compared to concrete mix with artificial Sand.

The Compressive Strength of Concrete mix with 100% Foundry Sand has decreased as compared to Concrete Mix with natural Sand. The % decrease is in the range of up to 6% as compared to concrete mix with natural Sand.

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PHOTOGRAPHS


PVP/CIVIL/CT/06


EXIT